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Emotional Expressivity and Working Memory Capacity

A Thesis

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Kathryn Kniele, M.S.

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ABSTRACT

Emotional Expressivity and Working Memory Capacity

Kathryn Tweedy, M.S.

Jacqueline D. Kloss, Ph.D.

There is a vast literature documenting the effects of emotion expression on physical, psychological and cognitive health. Among these studies is preliminary evidence suggesting that persons who express emotion enjoy gains in neurocognitive functioning, while persons who suppress emotion perform poorly on cognitive tasks. However, the link between the trait of emotional expressivity and cognitive function remains largely unexplored. The primary aim of this study was to examine such a relationship between trait expressivity and cognitive functioning. Specifically persons high in expressivity were expected to have greater working memory performance than persons low in expressivity. Additionally, it was thought that intrusive thinking thinking about stressful life events would mediate the relationship between emotional expressivity and working memory performance.

Seventy-four healthy, undergraduate men and women participated in this research study in exchange for extra credit for their psychology courses. The Berkeley Expressivity Questionnaire was used to assess individual levels of emotional expressivity. Working memory capacity was assessed via 1) the Digit Span Backwards portion of the Digit Span subtest from the Wechsler Adult Intelligence Scale – 3rd Edition and 2) Turner & Engle's (1989) Arithmetic Operation Word Memory Span Test. Participants also completed a series of self-report questionnaires assessing depressive, anxious, and intrusive thinking symptoms to determine the differential impact of depression, anxiety and intrusive thinking on working memory performance.

Multiple regression procedures revealed that overall trait expressivity was largely unrelated to working memory performance. However, individuals characterized as highly expressive about negative emotions performed worse on the Digit Span Backwards task than those who were less expressive about negative events. Positive expressivity was unrelated to working memory function. Findings from this study also support previous findings that intrusive thinking mediates the relationship between stress and working memory, but failed to support the hypothesis that emotional expressivity is a universally adaptive coping style that facilitates working memory functioning.

I. Introduction

Several converging lines of research suggest that emotional expressivity, the degree to which people outwardly display their emotions, influences physiological and psychological functioning (Rasmussen, 2003). Research to date concludes that emotion expression influences social interactions (Friedman & Riggio, 1981; Sullins, 1991, *see* Campos, Mumme, Kermoian, & Campos, 1994), psychological functioning (Gross & Levenson, 1997), and physical well-being (Ewart & Kolodner, 1994) (*see also* Pennebaker, 2003). Indeed, there is growing support for the psychological and physiological benefits of emotion expression. Whole books have been written exploring the beneficial effect of emotional disclosure through writing on immunity, physiological functioning and psychological (Lepore & Smyth, 2002; Pennebaker, 1997). A meta-analytic review of this literature concludes that these effects are substantial, reliable and warrant further investigation into the mechanisms underlying the link between emotion expression and health (Smyth, 1998).

Evidence is emerging that emotion expression and inhibition – active suppression of emotionally expressive behaviors -- are also related to neurocognitive functioning. Expression of emotions through writing is associated with improvements in working memory capacity (Klein & Boals, 2001a) and inhibition of emotions results in short-term visual memory deficits (Richards & Gross, 2000). Taken together, results of these experiments suggest that emotion expression may play a role in cognitive function. They also point toward a theoretical mechanism by which this may occur. To illustrate, emotion suppression results in an increase in intrusive thinking that depletes cognitive resources necessary to facilitate higher-level cognitive tasks, such as sustained and

divided attention, working memory and executive functions (Wegner, 1994; Wegner, Quillian & Houston, 1996). Alternatively, emotion expression lessens ruminative thinking about traumatic and everyday stressful experiences, reducing cognitive load and freeing cognitive resources to allow for enhanced neurocognitive functioning (Klein, 2002). Despite preliminary findings supporting the hypothesis that emotion expression facilitates working memory, no studies to date have investigated the specific nature of the relationship between individual differences in emotional expressivity and neurocognitive function. This link between expressivity and cognitive function is underdeveloped and warrants investigation.

Research in neuropsychology is making strides toward understanding the contributory role of personality in the experience of cognitive dysfunction. An understanding of the potential contributory individual factors, such as emotional expressivity, toward one's experience of cognitive dysfunction may be helpful in treating patients complaining of mild, medically unexplained symptoms of forgetfulness and impaired concentration. If it is found that persons low in emotion expression experience greater cognitive deficits than persons high in expression, interventions geared toward increasing expressivity among the former group would be empirically driven and may help to improve cognitive functioning among those with mild cognitive deficits.

The proposed study investigated the relationship between emotional expressivity and cognitive function. Specifically, it was hypothesized that emotional expressivity may predict the degree to which one experiences deficits in working memory. Because this relationship is likely to be most apparent under conditions of high stress (Kiecolt-Glaser, McGuire, Robles & Glaser, 2002), this study investigated the relationship between

emotional expressivity and working memory while taking into account individual levels of stress. Theoretical support for this research endeavor has been drawn from cross-discipline research in the fields of health psychology, neuropsychology and cognitive psychology. A review of this literature follows.

A. A Revolution in Emotion Research

Candace Pert, one of the leading scientists in psychoneuroimmunology (PNI) research, stated, "We're well into a [scientific] revolution, which has to do with incorporating the mind and emotions back into a science" (Moyers, 1993, p. 191). Now, a decade later, this revolution is in full effect. The past several years have seen a resurgence of interest in the area of emotions. There is growing momentum toward an understanding of how emotions affect biological, psychological, social and cognitive processes. This interest has been forged through a variety of research initiatives which collectively highlight the need for continued cross-discipline studies designed to illustrate how emotion may influence all aspects of functioning. Specific subfields in psychology have advanced the science of emotions by investigating their role in basic human processes. PNI studies demonstrate that one's experience of emotion plays an integral role in the mechanical workings of the immune system. For example, emotions provoke a sequence of neuroendocrine changes, producing ameliorative or deleterious effects on cardiovascular and immune functioning, depending on the chronicity and severity of the alteration (see reviews, Kiecolt-Glaser et al., 2002; Pelletier, 1992). There is agreement that the link the relationship between emotions and immunity is due in part to individual differences in coping styles. For example, Scheier & Bridges (1995) found that individual coping style, such as emotionally repressive coping, influences the onset and

course of illness. Findings in these studies point toward emotionally expressive coping as an influential factor in limiting disease progression (e.g., Stanton et al., 2000).

Growing interest in the relationship between emotion and neurocognitive functioning comes on the heels of advances in neuroscience enabling scientists to locate areas in the brain that are active in emotional processes. Neuroimaging studies have localized areas of the brain that affect and are affected by emotion. For example, Davidson and colleagues (2002) identified patterns of lateralized hemispheric activity that are associated with affective personality traits. Along these lines, multidisciplinary research has begun to explore how emotion regulation influences brain activity. There is mounting evidence that emotional and cognitive processes are interwoven in everyday life (Damasio, 1994). While emotions historically have been conceptualized as "pirates of logic," capable of interfering with one's ability to reason and act appropriately, emotions are now viewed as one regulatory aspect within a multifaceted system of biopsychosocial interactions (*see reviews*, Cacioppo & Gardner, 1999). Emotions appear to regulate cognitive functions such as attention, perception, reasoning and information processing (Campos et al., 1994), although the mechanisms are not entirely clear.

B. Emotional Expressivity

1. Conceptualizing Emotional Expressivity

Emotions may be conceptualized as impulses that have physiological, cognitive and behavioral correlates. To illustrate, fear elicits the physiological sympathetic "fight or flight" response, may be accompanied by particular thoughts (e.g., "This situation is dangerous."), and may elicit action (e.g., running). Individuals differ in the degree to which they act on these emotion impulses (Gross & John, 1997). While some people are

quite open and expressive, others are more reserved in their social expression of emotion. These differences are present from infancy (Kagan & Snidman, 1991; Weinberg, Tronick, Olson & Cohn, 1999) and represent a generalized response tendency in people that has been termed "emotional expressivity" ("EE").

Broadly conceptualized, EE refers to the degree to which an individual actively expresses emotional experience through verbal or nonverbal behaviors (Kring, Smith & Neale, 1994) and includes expression of both positive and negative emotions. According to Gross and John (1997), "an individual is emotionally expressive to the extent that he or she manifests emotional impulses behaviorally (p.435)." Emotional expressivity encompasses a broad range of verbal and nonverbal behaviors such as crying, making eye contact and frowning. Expressive behavior may be elicited in response to acute (falling and bruising your knee) or chronic (divorce proceedings) events, as well as to intrapersonal (feeling pain) or extrapersonal (seeing an accident) stimuli. As such, expressive behavior is most evident in the wake of stressors; it may occur in response to a variety of stimuli that elicit an emotional response either because they are perceived as aversive (distress) or because they are perceived of as pleasant (eustress). In sum, stressful events elicit a chain of psychophysiological responses or emotion states that a person may choose to act on or to suppress (Cacioppo & Gardner, 1999). These behaviors act, at least to some degree, as socially adaptive coping mechanisms.

a. Emotional expressivity as a trait coping style.

Functionalist theories of emotion emphasize this social-relational aspect of emotion and posit that emotions function as adaptive mechanisms (Campos et al., 1994; Greenberg, 2002). In other words, emotions incline an individual to act in certain ways,

and expression of feeling may facilitate coping and adjustment. To illustrate, crying out in an expression of pain encourages social interaction ultimately serveing to alleviate the pain or facilitate coping with it (i.e., child falls, cries and mother bandages and kisses wounded knee).

Coping is often characterized as the mediator of emotional reactions to stressful life events which serves different functions. For example, coping may facilitate problem solving, protect self-esteem, shape social interactions or regulate emotions (Folkman & Lazarus, 1988). Emotion regulation, a type of coping behavior, involves response selection and modification insofar as a person inhibits or expresses emotion physiologically, cognitively and behaviorally, as described above (Lepore, Greenberg, Bruno & Smyth, 2002). Thompson (1993) defines emotion regulation as the extrinsic and intrinsic processes responsible for monitoring, evaluating and modifying emotional reactions. Similarly, EE may be conceived as a trait manifestation of emotional regulation in that it describes an individual's tendency to self-regulate emotions through expressive behaviors (Kring, Smith & Neale, 1994). Expressing one's emotions about a stressful experience may be one way of engaging in emotional regulation (Creamer, 1995). In essence, EE refers to a trait coping style that lies on a continuum from active behavioral expression of emotional experience to suppression of emotion impulses.

2. Measuring Emotional Expressivity

An understanding of the core components of EE and a method of measuring the trait are essential to the success of studies investigating the role of EE in various human processes. Measures relevant to EE range from handwriting analysis and heart rate assessment to peer reports of expressive behavior and laboratory based analyses of facial

emotion expression in response to stimuli (Gross & John, 1997). However, self-report questionnaires are the most frequently used method of assessing expressivity. This method has proven to be a valid and reliable reflection of trait expressivity, as there is strong agreement between peer ratings of expressivity, physiological markers of expressivity, and responses to items on these questionnaires (Gross & John, 1997; Gross & John, 1998; Kring et al., 1994).

Debate continues regarding whether expressivity should be viewed as a unifactorial or multifactorial construct. While some have conceptualized expressivity as a simple unitary construct (a continuum from high to low expressive) (Kring, Smith & Neale, 1994), recent conceptualizations point toward a multifactorial model (Gross & John, 1998). Factor analysis of EE questionnaires demonstrates that expressivity loads on three factors: Positive Expressivity, Negative Expressivity, and Impulse Strength (Gross & John, 1997; King & Emmons, 1990; Trierweiler, Eid & Lischetzke, 2002). For example, respondents who endorse the following type of statements would score high on Impulse Strength: "I experience my emotions very strongly." Persons endorsing statements such as, "I laugh out loud when someone tells me a joke that I think is funny" would likely score high on Positive Expressivity. High scores on Negative Expressivity are obtained by affirmative responses to such statements as, "It is difficult for me to hide my fear." Although individuals do differ in the degree to which they express positive versus negative emotions, persons who typically express negative emotion also express more positive emotions as well (Gross & John, 1997).

Gross and John (1998) have produced the most comprehensive study to date in defining the domain of EE. They examined six self-report expressivity questionnaires

(Emotional Expressivity Scale, Emotional Expressivity Questionnaire, Berkeley Expressivity Questionnaire, Affect Communications Test, Affect Intensity Measure and Self-Monitoring Scale) and then evaluated the relationship between EE and group characteristics (i.e., sex and ethnicity), general personality traits (i.e., the Big Five), and affective psychological states (i.e., depressive affect, self-esteem and self-consciousness). In doing so, they confirmed a five-factor structure of general EE that is comprised of Expressive Confidence, Positive Expressivity, Negative Expressivity, Impulse Intensity and Masking. See Figure 1. Replicating previous work, they found that Core Emotional Expressivity includes Impulse Strength and Positive and Negative Expressivity. Positive and Negative Expressivity correlated with positive and negative affect, respectively, as measured by the Positive and Negative Affect Schedule (PANAS). In addition, Positive Expressivity was correlated with the Agreeableness and Openness to Experience subscales of the NEO Personality Inventory, while Negative Expressivity was correlated with the Neuroticism scale. In sum, it appears that questionnaire methods of assessing EE are reliable measures that demonstrate adequate convergent and discriminant validity in identifying individual differences in EE. These researchers also identified Expressive Confidence and Masking as aspects of EE. Expressive Confidence refers to one's ability to produce situation-appropriate emotion expressions, while Masking refers to one's attempts to conceal emotions from others. While Gross & John (1998) found that Expressive Confidence is associated with Extraversion and that Masking is associated with attempts to hide strong negative feelings, they conclude that Core Emotional Expressivity (Positive and Negative Expressivity and Impulse Strength) reflects the behavioral expression of emotion in everyday life. As such, this triad of Core Emotional

Expressivity is most salient in studies of the effects of emotion expressive behaviors on physical, psychological and cognitive health.

C. Emotional Expressivity, Health and Cognition

1. Emotional Expressivity and Health

The idea that EE may influence health outcomes is based in part on findings of early PNI studies. Although the findings are controversial, several researchers report that suppression of negative emotion may increase the risk of cancer or be a marker for cancer susceptibility (Gross, 1989; Kune, Kune, Watson, & Bahnson, 1991; Shaffer, Graves, Swank, & Pearson, 1987, Stanton et al., 2000). Alternatively confrontive coping (i.e., expressing anger) predicts a better chance of survival in breast cancer patients (Rodin & Salovey, 1989). Given these findings, it seems that coping styles that inhibit the disclosure of stressful or traumatic experiences are associated with poor physical health outcomes.

A greater understanding of the role of EE in social, psychological, and physical wellness arenas has emerged through these early investigations. Armed with a better conceptualization of the EE construct, researchers have sought to determine the clinical relevance of assessing EE in their patients and designed interventions to foster physical and psychological health by altering individuals' expressive behavior. Support for the regulatory role of EE has emerged through these investigations. Specifically, the importance of EE in facilitating social interaction is well-documented (Friedman & Riggio, 1981; Sullins, 1991), such that emotion expression promotes group cohesion. Emotional expressivity is associated with higher self-reported psychological well-being (Gross & Levenson, 1997) and emotion expression appears to attenuate depressive

symptoms (Lepore, 1997). The positive effects of emotionally expressive coping on health outcomes such as blood pressure, has been established (Ewart & Kolodner, 1994). Furthermore, there is an overwhelming literature documenting the beneficial effects of emotionally expressive writing on physical and psychological well-being (Pennebaker, 2003; Smyth, 1998). Collectively, results of these studies demonstrate that higher levels of expressivity are associated with better psychological, social and physiological outcomes.

2. Theoretical Explanations

Several theories exist as to why persons who act upon or express emotions report more positive social interactions, endorse greater feelings of well-being and demonstrate improved physical health. While each of these theories originates from a different perspective, they offer unique contributions to understanding EE from a biopsychosocial perspective. The functionalist theory emphasizes the social-relational aspect of EE and posits that expression of emotions surrounding stressful life events or traumas acts as an adaptive coping mechanism that elicits increased social support. Indeed, social support is known to be a moderating factor in the relationship between stress and health (Esterling, Kiecolt-Glaser, Bodnar & Glaser, 1994). Biologically based theories suggests that failure to express feelings results in high levels of negative affect which has physiological consequences such as changes in neuroendocrine and immunological pathways (Petrie, Booth & Pennebaker, 1998). Alternatively, cognitive psychological theories postulate that expression of emotions surrounding trauma or stressful events allows for integration of the event into existing schema (Foa & Kozak, 1986) and, in turn, allows one to draw meaning from the experience (Harvey, Orbuch, Chwalisz, & Garwood, 1991).

It is this cognitive organization theory that has garnered increasing attention recently. As referred to above, a vast literature exists documenting the beneficial effects of emotionally expressive writing on psychological and physical health outcomes (Lepore & Smyth, 2002). Specifically, writing about the thoughts and feelings surrounding stressful or traumatic events produces reliable positive effects on psychological functioning (i.e., reduced anxiety, depression) and physical functioning (i.e., increased immunity) (see review, Esterling, L'Abate, Murray, & Pennebaker, 1999). Expression of emotions surrounding stressful life events through writing appears to foster reorganization and integration of previously unattended to emotions and cognitions, resulting in improved psychological functioning and immunity (Lepore, et al., 2002). Clearly, there is abundant interest in understanding and explaining the relationships among emotions, expressivity and health. While the literature in this area continues to grow and documents the powerful positive effect of emotional disclosure through writing on various measures of health and well-being, little attention has been paid to the role that expression of emotions plays in higher-order cognitive processes such as attention, memory and executive functions.

3. Cognitive Consequences of Emotion Expression Versus Suppression

While little is known about the effects of emotion expression on cognitive function, preliminary evidence suggests that expression and, alternatively, suppression of emotion are related to neurocognitive function. Klein & Boals (2001a) investigated whether written emotional expression leads to gains in working memory. These experimenters tested two groups of undergraduates on a computerized working memory task at six intervals to determine whether an emotional disclosure writing intervention

would facilitate improvements in working memory, presumably by reducing stress. After seven weeks, the experimental group that had engaged in the emotionally expressive writing exercise demonstrated improvements in working memory compared to those assigned to a nonexpressive writing task (Klein & Boals, 2001a). Based on these findings, they concluded that the emotional aspects of stress, when unexpressed or suppressed, may compete for attentional resources, thereby causing poorer performance on working memory tasks.

Similarly, Richards and Gross (2000) demonstrated that suppression of emotion – the conscious inhibition of overt emotion expressive behavior -- results in decrements in memory functioning. Through a series of three experiments, these investigators documented decrements in memory functioning as a result of expressive suppression. Participants were randomly assigned to one of two groups and were required to watch an emotionally evocative film clip. The experimental group was instructed to avoid overt emotionally expressive behavior while watching the film; the control group was not restricted in their emotion expressive behavior and was instructed to simply watch the film. Persons instructed to suppress the emotions associated with watching the negative film clips demonstrated poorer memory for the content of the clips (Richards & Gross, 2000). Given these findings, the authors conclude that perhaps memory problems should be added to the list of negative consequences associated with inhibition of emotion impulses. Moreover, expression of emotions may enhance memory functioning, and particularly working memory, possibly because of the organizational, regulatory effect of expressive coping on such cognitive tasks. However, before discussing proposed

mechanistic models, it is important to understand the complex nature of working memory functioning.

D. Working Memory

1. Working Memory as a Limited Capacity System

The dynamic cognitive process of holding information in consciousness and applying that information toward goal-oriented actions is termed working memory (WM). Because information must be selected for storage and processing, inhibition of irrelevant information is a necessary consequence of WM processes. Pennington (1994) characterizes WM as a "limited capacity computational arena" (p.248) which is responsible for both storage and processing. While Pennington's model differs in complexity from other models of WM (e.g. Baddeley, 1996), the essential elements remain the same. First, WM is a prefrontally mediated process. Functional MRI studies demonstrate that cognitive tasks designed to tax WM are associated with increased prefrontal activity (Jonides et al., 1997), thus confirming that WM is a higher-level executive cognitive function. Second, WM is a limited capacity system. Performance on executive functions tasks such as WM, is dependent upon directed attention (Roberts & Pennington, 1996). Thus WM performance is dependent upon selection of relevant stimuli for processing and inhibition of irrelevant information.

The idea that attentional resources must be shared among task relevant and irrelevant demands is empirically supported (Teasdale et al., 1995). Attending to off-task demands depletes cognitive resources necessary for intact executive and WM functioning (Stoltzfus, Hasher, & Zacks, 1996). Several researchers have found that WM capacity and storage decreases in the presence of irrelevant, off-task, competing demands

(Blackwood, MacHale, Power, Goodwin & Lawrie, 1998). These off-task demands may take the form of external sensory inputs (i.e., visual or auditory stimuli). Similarly, internal stimuli such as thoughts (thinking about what to buy at the grocery store) or feelings (pain) may also compete for attentional resources. As such, WM is highly susceptible to the internal distractors wrought by life stress.

Individuals differ in their ability to perform WM functions and WM capacity is substantially related to measures of intelligence (Pennington, 1994). In fact, WM is predictive of IQ, particularly fluid intelligence measures, such that persons with high WM abilities perform better on reasoning, problem solving and novel computational tasks (Pennington, 1994). Conversely, impairments in WM affect one's ability to perform everyday tasks. Hasher & colleagues (1991) demonstrated that deficits in WM affect one's ability to speak logically, comprehend information, encode and retrieve memories, and to perform other complex cognitive tasks such problem-solving and reasoning. Apparently, one's ability to perform everyday cognitive tasks effects and is affected by WM capacity.

2. Stress and Working Memory

It is common for people to report mild to moderate cognitive symptoms such as difficulty concentrating, forgetfulness and impaired decision making in the wake of significant trauma (e.g., assault, death of a loved one). Clinical observations also suggest that these symptoms are commonly experienced by persons reporting a large number of everyday life stressors (e.g., caregiving, financial strain). Although it appears that significant trauma and the cumulative effect of a number of smaller stressors has a negative impact on neurocognitive functions, the mechanisms are unclear. What little is

known about the underlying mechanisms in the relationship between stress and cognitive function comes from studies of persons with acute anxiety or depressive disorders. The overall conclusion is that affective disorders are associated with decreased neurocognitive function (Darke, 1988; Sorg & Whitney, 1992). However, the direct relationship between life stress and cognitive function, or life stress and subclinical anxiety or depression, remains largely unexplored.

A series of studies investigating the effects of life stress on cognitive function demonstrate that higher levels of life stress are associated with impairments on WM tasks (Klein & Barnes, 1994; Klein, 1995; Klein & Boals, 2001b). In these studies, the investigators measured self-reported stress among undergraduate students and examined the relationship between stress and performance on problem solving and WM tasks. Persons reporting high levels of stress consistently performed worse on WM and problem solving tasks than persons reporting lower levels of stress. This relationship was especially strong when the demands of the WM task were high (Klein & Boals, 2001b).

3. Intrusive thinking as a mediator between stress and working memory deficits

One theory as to why stress affects performance on WM tasks and real-life problem solving points to intrusive thinking as a mediating factor. This theory, proposed by Klein (2002), suggests that the intrusive thinking that often accompanies stress acts as a distractor from the to-be-attended-to stimulus. As described above, WM refers to one's capacity to direct attention toward a stimulus or task while screening out irrelevant stimuli (Engle, Kane & Tuholski, 1999). Internal feeling states (e.g., hunger, pain, fatigue) and intrusive thoughts (e.g., thinking about items on your grocery list as you drive past the supermarket) may serve as distractors from a particular task at hand.

Insofar as persons reporting high levels of stress experience more intrusive thoughts that compete for attention with other, more relevant stimuli, they may be impaired on WM related functions.

It is common for individuals to ruminate over stressful events (Tait & Silver, 1989). An increase in intrusive and/or ruminative thinking is common following stressful experiences (*see review*, Horowitz, 1975). Wegner's (1994) ironic processing model states that suppression of emotionally evocative thoughts, such as those associated with stressors, results in sympathetic arousal. Suppression of these thoughts also results in a "rebound effect" – an increase in intrusive thoughts following suppression of the emotional stimulus – which has physiological (Wegner & Gold, 1995) and cognitive (Wegner & Erber, 1992; Wegner et al., 1996) correlates. Specifically, studying under cognitive loads leads to better memory for items that subjects were told to inhibit remembering compared to studying in the absence of cognitive load. These findings suggest that cognitive load increases intrusive thinking which has direct effects on one's ability to attend to, process and remember information.

The relationship between intrusive, ruminative thinking about stressors and negative mood has been well-established (e.g., Lutgendorf, Antoni, Kumar & Schneiderman, 1994; Tait & Silver, 1989). Ruminative thinking among persons with anxiety and depressive disorders is common. Not only do affective disorders such as anxiety and depression negatively affect one's ability to perform cognitive tasks, but personality traits such as anxiety, sensitivity to somatic symptoms and neuroticism are also associated with poor neuropsychological test performance (Boone & Lu, 1999; Bosma & Kessels, 2002). For example, empirical evidence demonstrates that anxiety

interferes with the storage and processing capacity of WM (e.g., Darke, 1988; Sorg & Whitney, 1992), presumably because anxiety-related intrusive, ruminative thinking interferes with one's ability to attend to task-relevant demands. Thus, it may be that persons who are predisposed to ruminative thinking, either because of transient psychopathology or because of stable personality traits, experience difficulty in performing everyday cognitive tasks, particularly when under stress.

Individuals vary in the degree to which they experience stress, and thus in the degree to which they would need to inhibit off-task demands (such as intrusive thinking) when performing WM functions. Several researchers have found that WM capacity and storage decreases in the presence of irrelevant, off-task, competing demands (e.g., Blackwood et al., 1998). For example, intrusive thoughts interfere with everyday tasks that are cognitively demanding such as proofreading (Baum, Cohen & Hall, 1993).

To date, few studies have examined the mediating effects of ruminative thinking on physical health and psychological well-being. While some have failed to clearly demonstrate this relationship (e.g., Paez, Velasco, & Gonzalez, 1999), much clinical and experimental data support the notion that cognitive processing of stressful experiences reduces intrusive thinking (Creamer, 1995; Greenberg, 1995; Harvey, Orbuch, Chwalisz & Garwood, 1991). For example, Lepore (1997) found that expressive writing attenuated the effect of intrusive thoughts on depressive symptoms in a population of students under acute stress, but did not lessen the frequency of intrusive thoughts per se.

Klein & Boals (2001b) are the only investigators to directly test the hypothesis that intrusive thinking mediates the relationship between stress and cognitive abilities. In a series of three experiments, they found that for persons reporting high levels of stress,

the frequency of intrusive thoughts was associated with impairments on WM tasks, and that the relationship between stress and WM capacity was mediated by intrusive thinking (Klein & Boals, 2001b). To illustrate, these investigators found that higher self-reported life stress as measured by the Life Experiences Scale (LES; Sarason, Johnson & Siegel, 1979) was positively correlated with WM performance on Turner and Engle's (1989) Arithmetic Operation Word Memory Span Task (OSPAN)[1]. They also found that intrusive thinking as measured by the Impact of Events Scale (IES; Horowitz, Wilner & Alvarez, 1979) was significantly associated with life stress and with OSPAN performance. Finally, they determined that the strength of the relationship between stress and WM performance was reduced when controlling for intrusive thinking. See Figure 2. As illustrated, Klein and Boals (2001b) conclude that intrusive thinking mediates the relationship between stress and WM performance.

E. Stress, Emotional Expressivity, and Working Memory

1. Klein's Model of Stress, Expressive Writing and Working Memory

Based on her studies of stress, working memory and written emotional disclosure, Klein (2002) has outlined a model of how expressive writing increases WM capacity. This model has four primary assumptions:

1. Memories of stressful experiences initially have different cognitive representations than memories of nonstressful experiences;
2. Stressful memories are highly accessible because they elicit intrusive thoughts;
3. Stressful memories consume attentional resources; and

1 Turner and Engle's (1989) OSPAN task is a computerized arithmetic and word span test. Subjects are instructed to read aloud simple arithmetic equations that are followed by a one-syllable word. Sets of 2-7 operations with associated words are presented, and subjects are required to write down as many of the words as they can remember at the conclusion of each set.

4. Developing a coherent narrative about a stressful experience reduces stress-related intrusive thinking, thereby freeing attentional resources for working memory tasks.

Klein's theory proposes that stressful life events are highly accessible via intrusive thoughts based on Wegner's ironic processing model. These intrusive thoughts compete for attentional resources, thereby compromising WM ability due to the fact that it is a limited capacity system. Because expressive writing promotes organization of stressful experiences and appears to reduce intrusive thinking about stressors, writing about stressors frees up cognitive resources that can be used to direct attention to relevant demands. Indeed, Klein's model provides a framework by which to test whether individual psychosocial variables influence the relationship between stress and WM. Specifically, Klein and her colleagues have demonstrated that WM declines under stress, and that an intervention designed to elicit emotion expression promotes improved WM function among stressed individuals. However, Klein's model fails to account for individual differences in coping style that may influence the relationship between stress and WM. As described previously, emotionally expressive coping leads to gains in physical and psychological health, and written emotional expression is associated with gains in WM. Given this, it would seem that individuals with emotionally expressive coping styles may be protected against the negative effects of stress and associated stress-related intrusive thinking. Because expression of emotions is a form of emotion regulation which attenuates the negative impact of stress on WM, it may be that persons who typically express emotions in response to stress – those high in EE -- may perform

better on higher-level cognitive tasks such as WM than those persons who are less emotionally expressive. See Figure 3.

F. Proposed Study

This study was an exploration and elaboration of Klein's model (2002). Collectively, experiments conducted by Klein and her colleagues suggest that expressive writing results in working memory improvements via decreases in intrusive thinking. Her model suggests that stress-induced intrusive thinking mediates the relationship between stress and WM. However, this model fails to account for individual differences in coping style, and precludes drawing any conclusions about who benefits the most from emotionally expressive writing.

Certainly, individuals respond differently to life stressors. While some individuals become overtly distressed over seemingly minor difficulties, others appear to withstand a great deal before their emotion responses are evidenced in behavior. As such, it is plausible that those who act on emotion impulses will experience fewer competing intrusive thoughts that could conceivably interfere with one's ability to sustain attention to relevant stimuli, compared to those who suppress the emotion impulses. Therefore, expression of emotions may free up cognitive resources needed for sustained attention in WM tasks.

One of the critiques of the expressive writing literature is that research has not determined for whom emotion expression interventions is beneficial. Klein's model proposes that expressive writing may be used as an intervention to reduce stress-related intrusive thinking and to improve WM abilities. However, it may be that emotionally expressive persons may benefit less from such an exercise than those who tend to inhibit,

suppress or do not act on emotion impulses, or vice versa. Inclusion of coping style as a predictor of working memory performance may add a new dimension to Klein's model of stress and working memory. To illustrate, see Figure 3. It is hypothesized that persons who typically express their emotions will experience less stress-related intrusive thinking and will perform better on WM tasks than persons who do not express emotions.

G. Summary and Implications

Little is known about the contributory role of personality factors toward neuropsychological functioning. Some studies attempted to correlate personality profiles with cognitive performance and other studies investigated the influence of affective disorders such as depression, anxiety on cognitive functioning (e.g., Boone & Lu, 1999; Bosma & Kessels, 2002; Darke, 1988; Greiffenstein & Baker, 2001). However, there is little understanding about how individual factors such as cognitive processing style, coping strategies, or specific personality traits contribute to one's overall cognitive functioning. As such, the relationship between EE and neurocognitive functioning is relatively unexplored.

Compelling research in the health psychology literature demonstrates that written emotional disclosure about past traumas has significant, positive and long-lasting effects on physical health (Francis & Pennebaker, 1992; Pennebaker & Beall, 1986; Pennebaker, Colder & Sharp, 1990; Pennebaker, Kiecolt-Glaser & Glaser, 1988). Recent theories regarding these findings point toward the role of emotion expression as an adaptive coping mechanism for reorganizing one's experience of stress or trauma. This theory has propelled investigations regarding the potential ameliorative effects of emotionally expressive writing on neurocognitive functioning. Thus far, only two studies (Richards

& Gross, 2000; Klein & Boals, 2001a) have investigated whether emotion expression has the same positive effects on cognitive functioning as it does on physical health. The results of both studies suggest that emotion expression is associated with cognitive improvements and that emotional suppression has negative cognitive consequences.

Klein's (2002) model of the relationships among stress, intrusive thinking and WM provides a forum for answering the question of whether coping factors may indeed influence cognitive function. Specifically, her model suggests that emotion expression enhances WM function, which is mediated by reductions in intrusive thinking. The proposed study is an attempt to clarify the relationships among trait emotional expressivity, intrusive thinking and neuropsychological functioning. Specifically, this study examined whether expressive persons perform better on tests of working memory, and assessed the mediating effects of intrusive thinking about stressful life events on this relationship. It was hypothesized that emotionally expressive coping would be associated with reduced impact of stress on WM, based on prior findings that emotion expression facilitates cognitive restructuring of stressful events and also reduces competing intrusive thoughts about stressful life events.

Because emotional expressivity is a multifactorial construct, the relationship between general emotional expressivity ("EE") and working memory was evaluated separately, in addition to the individual relationships among Positive emotional expressivity ("Positive expressivity"), Negative emotional expressivity ("Negative expressivity"), and working memory ("WM").

II. Statement of the Problem

Preliminary evidence suggests that emotion expression lead to gains in neurocognitive functioning, while emotion suppression reduces cognitive capacity, particularly working memory. However, whether individual differences in emotional expressivity influence cognitive function is unknown. Theoretically founded on Klein's (2002) model, this study aimed to 1) examine the relationship between general emotional expressivity and working memory, and 2) to test the theory that intrusive thinking about stressful life events mediates the relationship between emotional expressivity and working memory performance.

III. Hypotheses

Aim 1 Examine the relationship between emotional expressivity (EE) and working memory (WM).

Hypothesis 1a. EE (Berkeley Expressivity Questionnaire (BEQ) total score) will predict WM performance as measured by 1) Digits Backwards subtest of the WAIS-III (DPSAN) and 2) Arithmetic Operation Word Memory Span Test (OSPAN). This relationship will exist independent of individual differences in anxiety (as measured by the Spielberger State Anxiety Inventory (STAI-State) and depression (as measured by Beck Depression Inventory-II (BDI-II)).

Hypothesis 1b. Persons high in EE (BEQ Total) will perform better than those low in EE on both WM tasks (DSPAN, OSPAN).

Aim 2 Test whether intrusive thinking mediates the relationship between emotional expressivity and working memory

Hypothesis 2. Intrusive thinking (IES-Intrusion) about stressful life events will mediate the relationship between EE (BEQ Total) and WM (DSPAN, OSPAN).

Aim 3 (Exploratory) Explore relationships among positive and negative expressivity (as measured by the Positive and Negative Expressivity subscales of the BEQ) and performance on working memory (DSPAN, OSPAN) tasks.

Aim 4 (Exploratory) Examine the relationship between emotional expressivity (BEQ Total) and executive function (Stroop-CW)).

IV. Method

A. Participants

Participants were 74 healthy, undergraduate men (n = 32) and women (n = 42) ranging in age from 18 to 28 (M = 20.5, SD = 1.7). Power analyses confirmed that a sample size this large is sufficient to detect a moderate effect size (e.g., .15, .25, and .3) for multiple regression, multiple analysis of variance and correlational analyses, respectively, at .80 power.

Participants were recruited directly from psychology courses offered at a large urban, private university; recruitment extended over the course of approximately one year (September 2003 through July 2004). The majority of the sample identified themselves as non-Hispanic White (67.6%). Approximately 16% of the sample was African American. Nearly 14% self-identified as Asian or Pacific Islander. The remaining participants were Latino (1.4%) and Native American (1.4%). This distribution is comparable to the overall racial/ethnic distribution of students attending the host university.

The sample was fairly evenly divided among upper- and lowerclassmen: freshman (14.9%), sophomores (29.7%), juniors (37.8%) and seniors (17.6%). Participants were asked to provide their overall grade point average (GPA) if they were sure of what it was; 62 participants provided this information. GPAs ranged from 2.0 to 4.0 (on a 0 - 4.0 scale), with a mean of 3.3 (SD =.53).

Persons with a history of brain injury, loss of consciousness or neurological disease were prohibited from participating in this study as these conditions would likely affect WM performance. Only two volunteers were ineligible to participate; both were

excluded due to history of loss of consciousness. Nineteen students indicated that they take medication on a regular basis. These medications were predominantly oral contraceptives (n = 11), allergy or asthma agents (n = 3), antibiotics (n = 3), and antidepressants (n = 3).

B. Measures

1. Demographics and initial information form

Descriptive information, such as participants' age, gender, ethnicity, and year in school was collected. Women were also asked to provide the date of the first day of their last menstrual period for the purpose of conducting exploratory analyses regarding menstrual cycle related changes in cognitive and affective functioning.

2. Measures of emotional expressivity

Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1995). The Berkeley Expressivity Questionnaire is a 16-item self-report measure of individual differences in emotional expressivity. The BEQ provides three subscale scores (Positive Expressivity, Negative Expressivity and Impulse Strength), as well as a Total Expressivity score. The Positive Expressivity subscale is derived from responses to statements such as, "When I'm happy, my feelings show." The Negative Expressivity subscale is calculated based on responses to statements such as, "Whenever I feel negative emotions, people can easily see exactly what I'm feeling." The third subscale, Impulse Strength, provides a general measure of experience of emotion, and includes items such as, "I have strong emotions." Respondents are asked to rate how true each statement is for them on a likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Responses are averaged across items to yield values ranging from 1-7 for each scale.

The three-facet structure of the BEQ is preferable to unifactorial measures of expressivity due to accumulating evidence that negative affect is especially associated with measures of physical health and well-being. In a factor analytic study of various measures of expressivity, Gross & John (1998) confirmed the three-factor structure of the BEQ, and demonstrated that these three factors constitute what is referred to as Core Emotional Expressivity. Additionally, the BEQ shows convergent validity with peer ratings of general expressivity and the subscales differentially predict positive and negative emotion-expressive behavior in the laboratory (Gross & John, 1997). BEQ Total score was used to classify individuals along a continuum of expressivity in order to enable predictions regarding the influence of EE on WM performance. While BEQ total score was used to classify individuals along a continuum of expressivity, the differential predictive power of each of the subscales was also explored.

3. Measure of intrusive thinking

Impact of Events Scale (IES; Horowitz, Wilner & Alvarez, 1979). The IES was developed to assess subjective distress in response to a specific event. The Scale consists of 15 items, seven of which measure intrusive symptoms and eight of which measure avoidance symptoms. Respondents are asked to rate the items on a 4-point likert scale: 0 (not at all), 1 (rarely), 3 (sometimes) and 5 (often). The combination of Intrusion and Avoidance subscale scores yields a total subjective stress score ranging between 0 and 75. Criterion validity for the Intrusion and Avoidance subscales has been shown to detect change in individuals' clinical status over time (Horowitz, Wilner & Alvarez, 1979). Internal consistency alphas for the Intrusion subscale (.78) and the Avoidance subscale (.82) are high. The IES has been used in clinical samples to track change in

symptomatology over time; both subscales have been used in studies of intrusive thinking and thought suppression. For the purposes of this study, individuals' scores on Intrusion subscale were used as a measure of intrusive thinking to test the hypothesis that intrusive thinking mediates the relationship between total trait EE and WM performance.

4. Mood indices

Beck Depression Inventory-II (BDI-II; Beck, Steer & Brown, 1996). The BDI-II is a 21-item, multiple choice questionnaire that is used to assess the intensity of depressive symptoms. Respondents are required to rate the severity of symptoms they have experienced over the previous two-week period in accordance with DSM-IV criteria. The measure has been used extensively in clinical populations and community samples, and is among the most widely used depression screening instruments in research settings. Reliability estimates for the BDI-II in predicting depression in these populations is high (reliability coefficient = .92). The BDI-II was chosen for use in this study due to its clinical sensitivity as a screening measure for depression. Total score on the BDI-II was included as a predictor variable in regression analyses to determine whether EE predicts WM performance above and beyond depression.

Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger, 1983). This 40-item, self-report questionnaire provides two measures of anxiety -- state anxiety and trait anxiety. Trait anxiety refers to how anxious a person characteristically feels, while State anxiety refers to how anxious a person feels at any given moment. Both state and trait anxiety scales have been shown to have high reliability with median α coefficients of.92 and .90. While the state anxiety scale demonstrates variability over time, test-retest reliability for the trait portion of the scale ranges from .73 to .86. Because anxiety has

been shown to influence performance on cognitive tasks, the STAI was administered in order to determine the differential effects of state and trait anxiety on cognitive functioning as well as to assess differences in anxiety levels between high and low expressive persons. Individuals' state anxiety scores were entered as a predictor in the regression to evaluate whether EE predicts WM performance above and beyond anxiety.

5. Stress measures

Undergraduate Stress Questionnaire (USQ; Crandall, Preisler & Aussprung, 1992). The USQ is a self-report rating scale of current life stressors developed specifically for use with undergraduate populations. The scale contains 82 commonly experienced stressors (both eustress and distress items), and respondents are instructed to indicate which stressors they have experienced over the course of the past semester. Items from the questionnaire include the following: a) death of family member or friend; b) had lots of tests; c) no sleep; and d) had to ask for money. Endorsed items are assigned a score of "1", and the number of items endorsed is tallied to create a total score. The mean score of undergraduate students on the USQ is 17.63, with a standard deviation of 7.93. Scores between 16 and 23 are considered average, while persons scoring above 40 are indicative of very high levels of stress. The USQ demonstrates sensitivity to change in stress level over time (e.g., students scored higher on USQ during finals weeks as compared to beginning of term); test-retest reliability ranged from .59 to .69. In addition, undergraduate students rated items on the USQ as more complete and accurate in depicting common stressors than the Holmes-Rahe and the Daily Stress Inventory. The USQ will be used to quantify current level of stress in participants.

6. Tests of cognitive function.

Digits Backward (DSPAN; Wechsler Adult Intelligence Scale – 3rd Edition (WAIS-III), 1997). The Digit Span Backwards subtest from the WAIS-III is considered clinically to be a reliable measure of WM and has been used in research with a variety of populations to provide an index of WM capacity. The DSPAN task consists of a series of serially presented digits which the subject is required to repeat in reverse order. The digits are presented at the rate of one digit per second, and trials increase in difficulty from a two-digit sequence through a maximum of nine digits. Two trials are presented at each digit load level, such that after completion of two trials at the two-digit level, the next trial consists of three digits, etc. Raw scores on the DSPAN were used as an outcome measure of WM performance.

Arithmetic Operation-Word Memory Span Task (OSPAN, Turner & Engle, 1989). The OSPAN task has been used as a test of WM capacity and has high internal consistency (.75) and reliability (.88). This task consists of a series of simple arithmetic operations (e.g., (9 x 1) - 9 = 1) which is followed by a one-syllable word (e.g., back). Participants read the problem aloud and then indicate verbally whether the answer given to the problem is true or false. They then read the word aloud. The experimenter then advances the program to the next operation. After sets of two to seven problems, participants are prompted to write down as many of these words as possible from the previous set. Three sequences containing one set of each size are presented, for a total of 81 operations. Working memory scores are comprised of the total number of words recalled that are associated with correctly solved equations.

Stroop Color and Word Test (Stroop; Golden, 1976). The Stroop test is an easily administered screening instrument for identifying deficits in executive functioning. The Stroop has been used widely in both research and clinical settings to differentiate normal subjects from brain damaged subjects and as a direct test of executive functioning. Its reliability over time and validity as a screening measure for executive dysfunction has been well-established. Performance on the Stroop is associated with cognitive flexibility, resistance to interference from outside stimuli, creativity, and psychopathology—all of which influence an individual's ability to cope with cognitive stress. The test consists of 3 basic parts: Word page – the names of colors are printed in black ink; Color page – semantically meaningless symbols (X) printed in colored ink; and Word-Color Page - the words on the first page are printed in the colors on the second page with the restriction that the word and the color do not match. The subject's task is to look at each sheet and move down the columns, reading words or naming the ink colors as quickly as possible, within a given time limit. The test yields three scores, based on the number of items completed on each of the three stimulus sheets. An interference score, which is useful in determining the individual's cognitive flexibility, creativity, and reaction to cognitive stress, can also be calculated.

C. Procedure

Individuals were recruited directly from undergraduate courses at Drexel University with the help of two research assistants. The principal investigator and/or the research assistant presented information about the study to each class, describing it as an investigation of the role of personality in cognitive functioning. Interested individuals provided their contact information (name, telephone number, email address) and the

principal investigator and/or the research assistant contacted potential volunteers to schedule an appointment date/time to participate in the study.

All participants provided written informed consent to participating in the study. Study sessions took place in the Department of Psychology at Drexel University, Main Campus. The approximate time commitment of participants was one hour, during which time participants completed a series of self-report questionnaires (USQ, BDI-II, STAI, BEQ, and IES) and three neuropsychological tests (DSPAN, OPSAN and Stroop).

The cognitive measures were presented in counter-balanced order across subjects. Scoring of measures was done at the conclusion of the study so as to maintain blinding of experimenter to condition (high/low expressive individuals), thereby controlling for expectancy effects. Upon completion of the study, participants were provided with an extra credit voucher (worth 2 points) for the class from which they were recruited.

D. Data Analysis

Means, standard deviations and distribution of scores for all self-report questionnaires and cognitive measures were evaluated. Bonferroni-corrected t-tests were run to evaluate group differences (male versus female; high stress versus low stress) on all variables of interest. The “high” versus “mod/low” stress groups were derived based on a median split.

Two separate stepwise multiple regression analyses were performed with scores on the BDI-II, STAI-State and BEQ Total entered as predictor variables and raw scores on the DSPAN and OSPAN as dependent variables in order to evaluate the differential effect of anxiety, depression and EE on WM performance (Hypothesis 1a). Additional

regression analyses were run to evaluate the mediating effect of intrusive thinking on the relationship between stress and WM.

In order to evaluate Hypothesis 1b, participants were assigned to one of two groups (high EE versus low EE) based on a median split; subjects scoring above the sample mean on the BEQ Total scale were characterized as "high EE" and those scoring below the sample mean were characterized as "low EE." MANCOVA procedures were used to test the hypothesis that high EE persons would perform better on WM tasks than low EE persons, covarying for individual stress levels (USQ).

A series of post-hoc exploratory analyses investigated the relationship between EE and executive function and between Positive and Negative EE and performance on WM tasks. A 2 x 2 Multiple Analysis of Variance was performed with scores on Positive and Negative Expressivity subscales of the BEQ as independent variables and raw scores on the OSPAN and DSPAN as the dependent variables to evaluate whether the degree to which people expressed positive versus negative emotions differentially affected WM capacity. In addition, Pearson product-moment correlations were run to explore the relationship between EE and performance on the Stroop.

V. Results

A. Demographics and Descriptive Information

Table 1 presents means and standard deviations for all affective and cognitive measures for the entire sample. The range of scores on three of the BEQ indices (Negative Expressivity, Impulse Strength and Total Expressivity) was normally distributed, with mean values falling between 4.0 and 4.7 on a scale of 1 – 7. However, scores on the Positive Expressivity subscale were slightly skewed to the high end (M = 5.6, SD = .90). This range of values is consistent with those obtained by Gross & John (1995), such that the scores were normally distributed for Total Expressivity, Negative Expressivity and Impulse Strength, but skewed upward for Positive Expressivity. Ethnicity was unrelated to Total Emotional Expressivity [$F(2, 69) = .758$. $p = .47$], Negative Expressivity [$F(2, 69) = 1.12$, $p = .33$], Positive Expressivity [$F(2, 69) = 1.92$, $p = .15$], and Impulse Strength [$F(2, 69) = .19$, $p = .83$].

A score of greater than 24 on the USQ is indicative of high levels of objective stress (e.g., a higher than normal number of stressful events over the past week). The overall mean USQ score of this sample was 24.12 (SD = 10.58). Similarly, the mean score on the IES (M = 39.68, SD = 14.02) indicated moderate levels of subjective stress. Individual subscale scores on the IES Intrusion (M = 19.59, SD = 9.27) and Avoidance (M = 19.97, SD = 7.80) were comparable to those obtained by Horowitz and colleagues (1979) in their validation study of the measure.

Participants also scored within normal limits on most affective measures. Specifically, overall mean score on the BDI-II was 10.65 (SD = 7.0), indicating minimal depressive symptomatology in this sample. Mean scores on the STAI – State subscale

(M = 36.77, SD = 9.26) and the STAI – Trait subscale (M = 41.1, SD = 8.60) were within the expected range of scores for an undergraduate sample.

1. Between sex comparisons

Men and women differed in the degree to which they were emotionally expressive. Total scores on the BEQ were higher and less evenly distributed among women (M = 5.00, SD = .77) than men (M = 4.28, SD = .92). As can be seen in Table 1, men also scored uniformly lower than women on three of the four expressivity indices, with significant group differences on the negative expressivity, impulse strength, and BEQ total scales. There were no significant between sex differences on any other affective or cognitive variables. As such, gender was not used as a covariate in subsequent analyses.

2. Between group comparisons based on level of stress

Stress has been shown to differentially affect performance on cognitive tasks and on self-reported mood indices. To evaluate the impact of objective stress on cognition and affect, participants were reassigned to one of two groups based on reported objective stress and group comparisons were performed for all variables. Persons scoring greater than 24 (sample mean) on the USQ were categorized as “high” stress and those scoring at or below 24 on the USQ were categorized as “low/moderate” stress. Bonferroni corrected t-tests were run to determine whether those reporting high levels of stress differed on any affective and/or cognitive variables from those reporting low to moderate levels of stress. As can be seen in Table 1, several significant group differences emerged. Specifically, the high stress group indicated a greater number of intrusive thoughts (IES Intrusion; M = 23.39, SD = 7.20) than the low/moderate stress group (IES Intrusion; M =

16.00, SD = 9.65), p < .001. In addition, scores on the BEQ Impulse Strength subscale were higher among the high stress group (M = 4.88, SD = 1.17) than among the low/moderate stress group (M = 4.12, SD = 1.16), p < .01. State anxiety scores were also significantly higher among highly stressed individuals (M = 39.14, SD = 9.80) than among the low/moderately stressed individuals (M = 34.53, SD = 8.23) p < .05.

3. Intercorrelations among affective and cognitive variables

Because several of the variables of interest in this study are known to be correlated (i.e., depression and anxiety), Pearson product-moment correlations were run for all affective and cognitive variables. As expected, all BEQ scales were significantly intercorrelated (rs = .52 - .86, ps <.001), indicating that each scale taps a unique component of a single construct – emotional expressivity. Intrusive thinking was also positively and significantly correlated with self-reported objective stress (USQ; r = .41), depressive symptomatology (BDI-II; r = .28), current anxiety (STAI-State; r = .43) and trait anxiety (STAI-Trait; r = .44), all ps < .05. In addition, higher levels of depressive symptoms (BDI-II) were associated with state and trait anxiety, rs = .50 and .68, respectively, ps < .001. See Table 2, which presents intercorrelation values for all affective variables.

Scores on the OSPAN and DSPAN tasks were significantly and positively correlated with each other (r = .49, p < .001), indicating that these two tasks measure similar yet distinct functions. However, while the Stroop CW was correlated with the DSPAN task (r = .24, p < .05), it was not associated with performance on the OSPAN task. While these results are certainly not conclusive, they indicate that the DSPAN task likely taps into both the WM and executive function cognitive domains.

B. Analysis of Primary Hypotheses

1. Hypothesis 1a. Emotional expressivity (BEQ Total) will predict working memory performance (OSPAN, DSPAN) above and beyond anxiety (STAI-State) and depression (BDI-II).

Scores on the BDI-II and STAI-State were significantly correlated with each other, but were not significantly related to performance on the OSPAN or DSPAN tasks. BEQ Total was also not correlated with OSPAN or DSPAN performance. See Table 3, correlation matrix for variables included in regression analyses. As such, the regression models containing STAI-State, BDI-II and BEQ Total as predictors of OSPAN and DSPAN performance were nonsignificant, $Fs(3,70) = .58$ and .24, respectively, $ps > .05$.

Intrusive thinking (IES-Intrusion) was positively correlated with OSPAN performance ($r = .24$, $p < .05$); however, controlling for intrusive thinking failed to bring the relationship between EE (BEQ Total) and WM (OSPAN) to significance, $r = .06$, $p = .60$. Intrusive thinking was not significantly correlated with DSPAN performance, $r = .03$, $p = .79$.

2. Hypothesis 1b. Persons high in emotional expressivity (BEQ Total) will perform better than those low in emotional expressivity on both working memory tasks (DSPAN, OSPAN).

MANCOVA procedures failed to demonstrate a significant main effect for high EE ($n = 32$) versus low EE ($n = 42$) groups on WM (OSPAN, DSPAN) performance, controlling for stress (USQ), $F(2,70) = 1.31$, $p = .28$. Considering the possibility that the relationship between EE and WM may be a quadratic one where extremely high EE and extremely low EE persons may perform better or worse than those in the moderate range of EE, exploratory analyses were run to test this hypothesis. Persons scoring beyond ± 1 standard deviation from the mean on the BEQ Total were categorized as “extreme EE” (n

= 50); those within +1 standard deviation of the mean were considered "moderate EE" (n = 24). ANCOVA analysis with extreme EE versus moderate EE as the independent variable, OSPAN as the dependent variable, and USQ as a covariate failed to demonstrate a significant main effect, $F(1,73) = .903$, $p = .35$. Similar analyses were run using DSPAN as the dependent variable without covarying for stress level, as stress was unrelated to DSPAN performance. Again, results were nonsignificant, $F(1,73) = .211$, $p = .65$.

Visual inspection of the relationship between EE and WM corroborated these results. See Figure 4, 2 X 2 scatter plots of BEQ Total scores by OSPAN and DSPAN performance.

3. Hypothesis 2. Intrusive thinking about stressful life events (IES-Intrusion) will mediate the relationship between emotional expressivity (BEQ Total) and working memory (OSPAN, DSPAN) such that the more intrusive thoughts a person has about stressful life events the poorer their performance will be on tasks of working memory.

Because the relationships between EE and WM performance were nonsignificant, the mediation analysis was unwarranted and therefore, not performed. However, stepwise regression analyses confirmed that intrusive thinking mediates the relationship between stress and WM in accordance with Baron & Kenny's (1986) criterion for mediation. Objective stress (USQ) was significantly related to both WM (OSPAN) and intrusive thinking (IES-Intrusion), $rs = .28$ and .41 respectively, $ps < .01$. Intrusive thinking (IES-Intrusion) was also significantly related to WM (OSPAN; $r = .24$, $p < .05$). The strength of the association between stress (USQ) and WM (OSPAN) was reduced to nonsignificance ($r = .21$, $p > .05$) after controlling for intrusive thinking (IES-Intrusion).

C. Exploratory Analyses

1. Differential effects of positive and negative expressivity on working memory

Post-hoc analyses explored the relationships among positive and negative expressivity and performance on WM tasks. Data were recoded based on a median split for both the Positive Expressivity subscale and the Negative Expressivity subscale of the BEQ. MANOVA procedures with Positive and Negative Expressivity entered as independent variables and raw scores on the OSPAN and DSPAN as dependent variables were performed. A significant main effect emerged for Negative Expressivity ($F(1,73) = 8.87$, $p < .01$), with persons scoring above the mean on the Negative Expressivity subscale ($n = 42$) performing significantly worse ($M = 6.5$, $SD = 2.27$) than persons scoring below the mean ($n = 32$) on the DSPAN ($M = 8.0$, $SD = 2.90$), but not the OSPAN. There was no significant main effect for Positive Expressivity, $F(2,69) = 2.72$, $p = .073$; the interactive effect of Positive and Negative Expressivity on WM performance was also nonsignificant, $F(2,69) = .306$, $p = .74$.

As described previously, women scored the higher range of expressivity on Total Emotional Expressivity, as well as the Negative Expressivity and Impulse Strength subscales of the BEQ. This, together with the finding that persons high in Negative Expressivity performed worse on the DSPAN task than those low in Negative Expressivity, it was thought that there may be a sex-specific relationship between Negative Expressivity and working memory performance. Specifically, it was thought that the relationship between Negative Expressivity and working memory may be stronger in women than in men. However, bivariate Pearson product-moment correlations failed to demonstrate a significant sex-specific relationship between

Negative Expressivity and performance on either the DSPAN or the OSPAN tasks, all p's > .05.

2. Relationships among Stroop and affective variables

Performance on the Stroop Color Word test (Stroop CW) was significantly and positively correlated with objective stress (USQ; r = .28, p < .05) and intrusive thinking (IES-Intrusion; r = .24, p < .05). As stated previously, the USQ and IES-Intrusion scales were also significantly related. Given this, mediation analyses were performed to determine whether intrusive thinking mediates the relationship between stress and executive functioning as measured by the Stroop CW. While the strength of the relationship between stress and Stroop performance was reduced after controlling for intrusive thinking, this change was nonsignificant.

3. Menstrual cycle related cognitive and affective functioning in women

Menstrual cycle phase for women was determined by counting forward from reported first day of last menstrual period ("LMP"). Cycle phases were defined as follows: menstrual phase, days 1-7; follicular phase, days 8–22; and luteal phase, days 23-31. Women who did not report LMP or whose LMP was greater than 31 days prior to the date of study participation were excluded from these analyses. Thus, a total of 39 (of 42) women were included in these analyses. Cycle phases were nearly equally represented with 14 women estimated to be in the menstrual phase, 13 women in the follicular phase and 12 women in the luteal phase.

Multiple Analysis of Variance with cycle phase (menstrual, follicular, luteal) as the independent variable and scores on all four Berkeley Expressivity Questionnaire scales (Total, Positive and Negative Expressivity and Impulse Strength) as the dependent

variables failed to show significant cycle-phase effects for Emotional Expressivity, all p's > .05. A second 3 (cycle phase) X 3 (OSPAN, DSPAN, Stroop CW) MANOVA failed to show a significant relationship between cycle phase and performance on cognitive tasks, all p's > .05. There were also no significant relationships between cycle phase and self-reported anxiety (STAI), depression (BDI-II), objective stress (USQ) or intrusive thinking (IES – Intrusion).

VI. Discussion

A. Summary of Results

Results of this study confirm that stress-related intrusive thinking mediates the relationship between stress and working memory. It was also found that stress negatively impacts performance on higher level, executive function tasks, though the mediation model of intrusive thinking on the relationship between stress and executive functioning was not borne out. Contrary to hypotheses, individual differences in overall emotional expressivity (BEQ Total) were not significantly related to WM capacity, nor were they associated with intrusive thoughts about stressful life events. Interestingly, however, persons identified as highly expressive regarding negative emotions performed worse on the Digit Span Backwards task than those identified as less expressive about negative emotions. Positive emotion expression was unrelated to performance on either WM task. Predictably, and as demonstrated in prior studies (e.g., Kring & Gordon, 1998), women as a group scored higher than men on two measures of EE – negative expressivity and impulse strength. Expression of positive emotion was not significantly different between sexes.

B. Support for Klein's (2002) Model

These findings support Klein's (2002) model of stress, expressive writing and working memory. Klein proposed that expressive writing attenuates the negative impact of stress on WM capacity via a reduction in stress-related intrusive thinking. Results of this study, as in Klein's studies, demonstrate that higher levels of self-reported event stress are associated with poorer working memory performance as measured by the OSPAN task, and that intrusive thinking about stressful events mediates the impact of

stress on WM performance. This model remains undisputed by results of the present study; in fact, these results further validate the findings of Klein and colleagues related to the impact of stress on working memory.

The present research was designed not to challenge Klein's model, but rather to evaluate the relationships among emotion expression, stress, intrusive thinking and working memory from a different vantage point. The unique contribution of this study is that it evaluated whether individual differences in trait EE – the degree to which one typically expresses emotion – impacts WM performance, just as engaging in an expressive writing intervention does. It was hypothesized that those who typically cope with stress by expressing their emotions may be less susceptible to intrusive thoughts about their emotions and, therefore, would have greater WM capacity than those who inhibit or suppress emotion impulses. The present findings failed to support this hypothesis. Overall emotional expressivity was unrelated to cognitive functioning. However, significant differences between high and low expressive persons emerged when evaluating the relationship between the subcomponents of expressivity (i.e., positive and negative expressivity) and cognitive function. Persons considered highly expressive in response to negative emotions performed worse on one index (Digits Backwards of the WAIS-III) of WM than those who were low in negative emotion expression.

C. Unique Aspects of Negative Expressivity

This finding stands in contrast to previous findings suggesting that organization and/or cognitive restructuring of negative emotional events via expression of emotions frees up cognitive resources – a theory put forth by Foa & Kozak (1986) and elaborated

on by Klein (2002). Based on this theory, one may expect that higher levels of expressivity about negative events would be associated with comparatively better working memory performance than lower levels of expressivity about negative events. Indeed, the beneficial effects of written emotional disclosure – a form of EE – surrounding traumas are quite clear. However, the opposite was demonstrated in this study – persons highly expressive about negative emotions performed worse on one measure of working memory. This would suggest that the benefits of emotion expressive interventions (such as expressive writing about past trauma) may be more salient for those persons who do not typically express their emotions about negative life events. It is also possible that the beneficial effects of negative emotion expression are facilitated only when emoting occurs in a structured or organized way. In other words, simply "venting" about negative life events may be largely unproductive, perhaps even destructive, while emoting through repeated writing exercises with clear limits and instructions (such as those outlined in Pennebaker's expressive writing paradigm) may be beneficial, leading to increased cognitive organization (Foa & Kozak, 1986), reduced intrusive thinking (Klein, 2002) and, potentially, improvements in cognitive functioning (Klein, 2001a).

D. Limitations and Future Research

There are some limitations of this research that are noteworthy and which should be addressed in future investigations. First, and most importantly, these data are largely self-report and thus subject to response bias on the part of respondents. Although the self-report measures used in this research were chosen based on their well-established validity and reliability, it is possible that some participants provided skewed self-evaluations. Future studies may want to focus on objective measurement of the major

constructs such as emotional expressivity and intrusive thinking via physiological or behavioral measures.

Another point to consider is the relationship between IQ and working memory. Working memory is substantially related to fluid measures of intelligence (Pennington, 1994); in fact, the Wechsler Adult Intelligence Scale – 3rd Edition draws on performance on working memory tasks to compute Full Scale and Performance IQ scores. It may be that individuals who are intrinsically better at working memory tasks, and considered to have greater cognitive reserve than those with lower IQ scores, may be less susceptible to the deleterious effects of stress on cognitive functioning. The positive benefits of emotionally expressive coping may be more evident in those persons whose working memory functioning is poor to borderline at baseline. This study did not control for individual differences in overall intelligence. However, this may be something to evaluate not only in future studies of emotional expressivity and cognitive functioning, but also when investigating the relationship between cognitive functioning and stress.

Finally, it is important to consider the difference between objective and perceived stress and the differential impact each may have on psychological functioning and cognitive performance. In this study, stress was measured using the Undergraduate Stress Questionnaire (Crandall, Preisler & Aussprung, 1992) – a measure that characterizes an individual's level of stress based on number of reported stressful events occurring within the past semester. This method of measuring stress was chosen for two reasons. First, this stimulus approach to stress measurement has been shown to predict both physical and mental health (Lazarus & Folkman, 1984). In addition, prior research investigating relationships among stress and cognitive functioning demonstrates that

objective or stimulus-based stress is associated with measurable differences in cognitive functioning and mood (i.e., Klein & Barnes, 1994). However, number of stressful events does not always translate into equivocal levels of perceived stress among individuals. Differences in situation appraisal, cognitive attributions and/or coping style may result in varying degrees of perceived stress (Lazarus & Folkman, 1984). For example, losing twenty dollars – an event most would consider to be stressful -- may be *perceived* as a highly stressful event by one person and as only a minor inconvenience by another person. Thus, assessment of individuals' *perceived* level of stress may provide a more accurate estimate of distress.

In this study, we demonstrated that objective, or life event stress, was related to performance on at least one working memory task, but was unrelated to emotional expressivity or affective functioning. It may be that expression of emotions is elicited not only in response to a stressful event, but rather is at least partially dependent upon perceived importance of that stressful event. As such, it would be interesting to evaluate whether perceived stress is more predictive of mood and performance on cognitive tasks than simple life event stress.

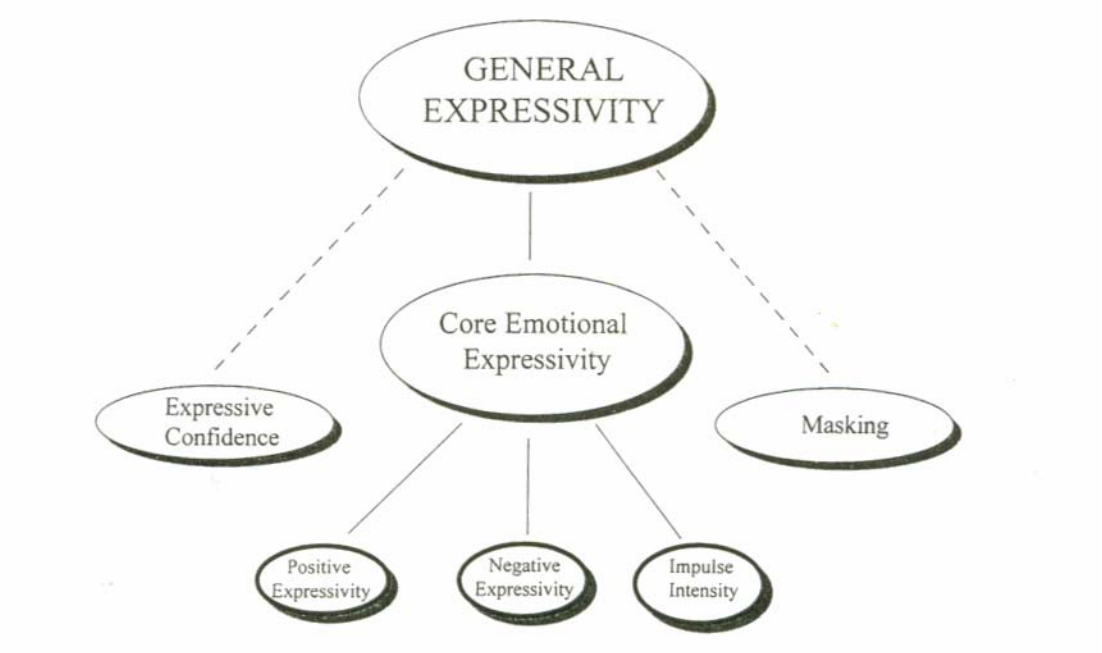


Figure 1. Hierarchical structure of the domain of expressivity.

Note. Figure taken from Gross, J.J., & John, O.P. (1998). Mapping the domain of expressivity: Multimethod evidence for a hierarchical model. Journal of Personality and Social Psychology, 74, 170-191.

Figure 2. An illustration of Klein & Boals (2001b) study of stress, intrusive thinking and working memory.

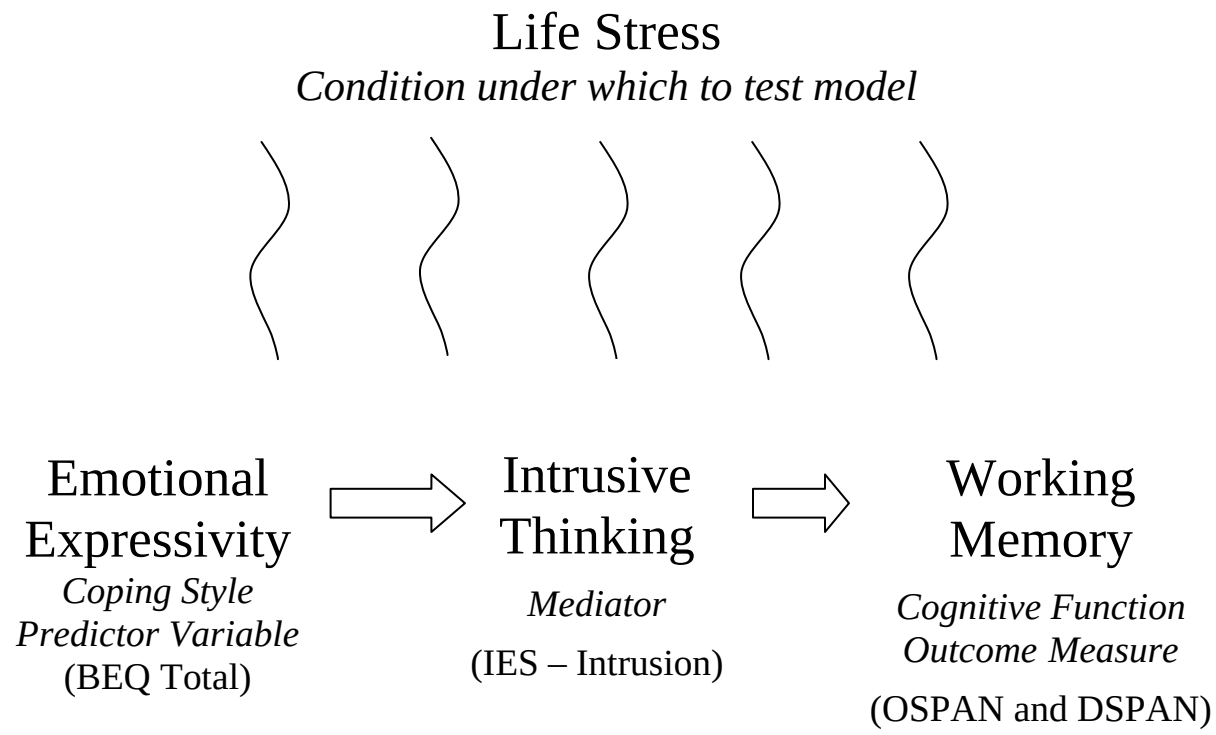


Figure 3. Illustration of proposed relationships among emotional expressivity, intrusive thinking and working memory, under conditions of life event stress.

Table 1
Group differences on all affective and cognitive variables

		Group Means (SD)			
Variable	**Total Sample** (N = 74)	**Men** (n = 32)	**Women** (n = 42)	**Low/Mod Stress** (n = 38)	**High Stress** (n = 36)
BEQ Total	4.69 (.90)	**4.28 (.92)*** **	**5.00 (.76)*** **	4.51 (.92)	4.88 (.86)
BEQ Negative	3.96 (.97)	**3.60 (.98)** **	**4.24 (.87)** **	3.86 (1.05)	4.07 (.87)
BEQ Positive	5.62 (1.01)	5.36 (1.14)	5.82 (.87)	5.54 (1.09)	5.71 (.94)
BEQ Impulse Strength	4.49 (1.21)	**3.89 (1.11)*** **	**4.94 (1.09)*** **	**4.12 (1.16)** **	**4.88 (1.17)** **
USQ Total	24.12 (10.58)	24.91 (10.28)	23.52 (10.89)	**15.68 (5.21)*** **	**33.03 (6.78)*** **
IES Total	39.68 (14.02)	37.56 (14.01)	41.29 (13.98)	**35.58 (14.75)** **	**44.00 (11.94)** **
IES Intrusion	19.59 (9.27)	17.69 (9.43)	21.05 (8.98)	**16.00 (9.65)*** **	**23.39 (7.20)*** **
IES Avoidance	19.97 (7.80)	18.94 (7.96)	20.76 (7.69)	18.79 (7.62)	21.22 (7.90)
BDI-II	10.65 (6.97)	11.00 (5.98)	10.38 (7.70)	9.82 (5.66)	11.53 (8.11)
STAI (state)	36.77 (9.26)	36.09 (8.46)	37.29 (9.90)	**34.53 (8.23)***	**39.14 (9.80)***
STAI (trait)	41.15 (8.60)	40.78 (8.11)	41.43 (9.03)	39.42 (8.13)	42.97 (8.81)
Digit Span Backwards	7.84 (2.63)	7.53 (2.71)	8.07 (2.58)	7.34 (2.61)	8.36 (2.59)
STROOP color-word	50.15 (11.95)	49.59 (10.36)	50.57 (13.14)	48.79 (9.82)	51.58 (13.85)
OSPAN Total	49.41 (9.86)	48.88 (9.89)	9.94 (1.53)	47.71 (8.91)	51.19 (10.60)

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 2
Pearson intercorrelations among affective variables

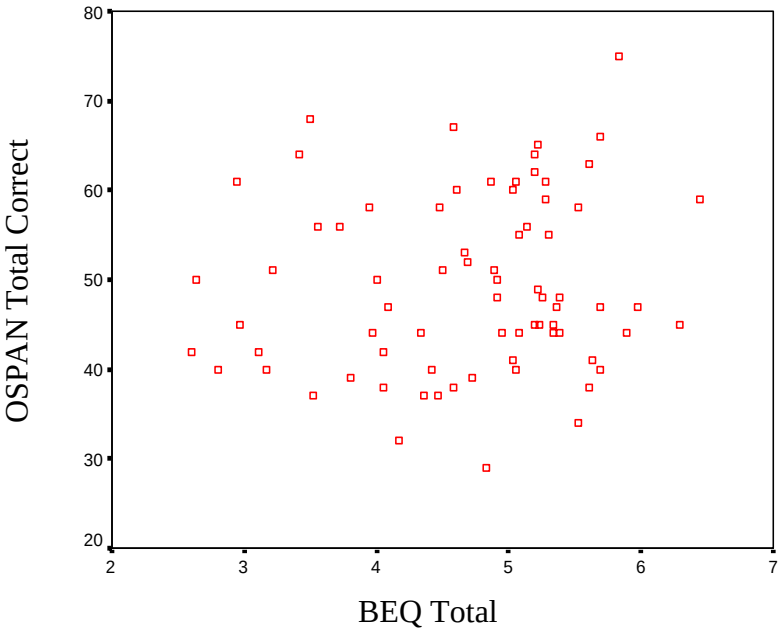
		Affective Variables									
		BEQ TOTAL	BEQ NEG	BEQ POS	BEQ IS	USQ TOTAL	IES INTRU	IES AVOID	BDI-II	STAI STATE	STAI TRAIT
BEQ TOTAL	r	1									
BEQ NEGATIVE	r	.86**	1								
BEQ POSITIVE	r	.84**	.64**	1							
BEQ IMPULSE STRENGTH	r	.85**	.58**	.52**	1						
USQ TOTAL	r	.17	.05	.07	.28*	1					
IES INTRUSION	r	.30**	.23	.10	.41**	.41**	1				
IES AVOIDANCE	r	.04	-.07	-.05	.18	.19	.42**	1			
BDI-II	r	-.04	-.03	-.21	.11	.19	.28*	.15	1		
STATE ANXIETY	r	.03	.06	-.20	.18	.28*	.43**	.13	.50**	1	
TRAIT ANXIETY	r	.20	.17	-.07	.39**	.32**	.44**	.15	.68**	.47**	1

* $p < .05$, ** $p < .01$

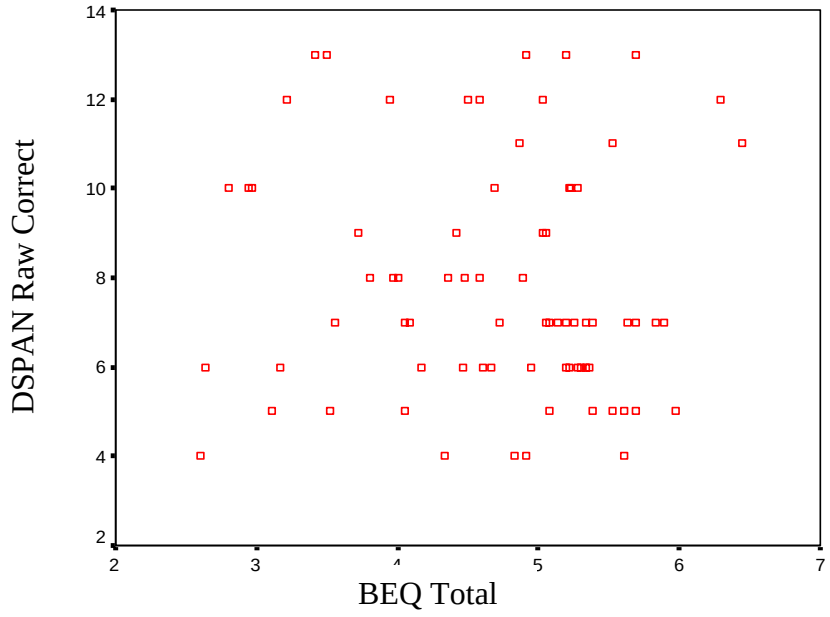
Table 3
Pearson partial correlations of variables included in regression analyses

	Variable						
	OSPAN	DSPAN	STAI-State	BDI-II	BEQ Total	IES Intrusion	USQ Total
OSPAN	1						
DSPAN	.49***	1					
STAI-State	.09	-.08	1				
BDI-II	.05	-.01	.50***	1			
BEQ Total	.13	-.06	.03	-.04	1		
IES Intrusion	.24*	.03	.43***	.28*	.30**	1	
USQ Total	.28*	.12	.28*	.19	.17	.41**	1

* $p < .05$, ** $p < .01$, *** $p < .001$



BEQ Total X OSPAN Total Correct



BEQ Total X DSPAN Raw Correct

Figure 4. 2 X 2 scatter plots of BEQ Total scores by OSPAN and DSPAN performance.

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VITA

Kathryn Kniele (*formerly Tweedy*)

Education

Ph.D.	October 2004. Drexel University, Philadelphia, PA Clinical Psychology, Neuropsychology emphasis
M.S.	October 2002. Drexel University, Philadelphia, PA Clinical Psychology, Neuropsychology emphasis
B.S.	May 1995. University of Scranton, Scranton, PA Psychology major, Philosophy minor, *cum laude*

Clinical Experience

2004 –	*Postdoctoral Fellow,* University of Pennsylvania, Dept. of Psychiatry
2003 – 2004	*Psychology Intern,* Medical University of South Carolina
2002 – 2003	*Psychology Clerkship,* Children's Seashore House, Dept. of Psychology
2002 – 2003	*Neuropsychology Clerkship,* Moss Rehabilitation Hospital
2001 – 2002	*Neuropsychology Clerkship,* Diversified Psychological Resources
1997 – 1999	*Research Coordinator,* University of Pennsylvania, Dept. of Psychiatry
1995	*Recreation Assistant,* Lackawanna Association for Retarded Citizens
1994	*Testing Volunteer,* Friends Hospital, Psychology Department

Publications

Morrison, M.F., Kallan, M., Ten Have, T., Katz, I., **Tweedy**, K., & Battistini, M. (2004). Lack of efficacy of estradiol for depression in postmenopausal women: A randomized, controlled trial. Biological Psychiatry, 55, 406-412.

Tweedy, K., Morrison, M.F., & DeMichelle, S.G. (2002). Depression in older women. Psychiatric Annals. 32(7), 417-429.

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Horner, M.D., Ferguson, P.L., Selassie, A.W., Labbate, L.A., **Tweedy**, K. & Corrigan, J.D. (In Press). Patterns of alcohol use one year after traumatic brain injury: A population-based, epidemiological study. Journal of the International Neuropsychological Society.

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Kloss, J.D., **Tweedy**, K., & Gilrain, K. (2004). Psychological factors associated with sleep disturbances among perimenopausal women. Behavioral Sleep Medicine, 2, 177-190.

Awards and Honors

University of Scranton Loyola Scholarship

Dean's List, University of Scranton, Fall 1992 – Spring 1995

Pennsylvania Psychological Association Education Award – 2002

1st Place Student Research, 9th Annual Graylyn's Conference on Women's Cognitive Health